HYBRIDIZATION OF SILHOUETTE RENDERING AND PEN-AND-INK ILLUSTRATION OF NON-PHOTOREALISTIC RENDERING TECHNIQUE FOR 3D OBJECT

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A dissertation submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computing
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JANUARY 2017

An appreciation for my beloved father and mother, Mat Noor bin Bidin and Che Norriya bin Che Abdullah and my lovely family. Big thanks to all of my friends for their support towards me to accomplish this dissertation. Thank you for all.

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ACKNOWLEDGEMENT

In process of completing my dissertation, a lot of people had involved such as the academician, researchers, and practitioners in order of giving me the understanding of my research study. My sincere appreciation to my Supervisor, **Dr.Norhaida bte Mohd Suaib** for the good supervision, guidance and advices during my research study.

Special thanks to Perpustakaan Raja Zarith Sofea in Universiti Teknologi Malaysia, for supplying the sources of literature review and thanks to the librarians for their assist in order to look for the relevant literature.

An appreciation extends to the fellow postgraduates for their support and my colleague for their assistance in various points. Last but not least, big thanks to my family member for their encouragement.

ABSTRACT

This study proposes a hybrid of Non-photorealistic Rendering techniques. Non-photorealistic Rendering (NPR) covers one part in computer graphics that caters towards generating many kinds of 2D digital art style from 3D data, for instance output that looks like painting and drawing. NPR includes the painterly, interpretative, expressive and artistic styles, among others. NPR research deal with different issues such as the stylization that are driven by human perception, the science and art that were brought together and being harmonized with techniques used. Some of approaches used in NPR were discussed such as cartoon rendering, watercolour painting, silhouette rendering, pen-and-ink illustration and so on. A plan for hybridization of NPR techniques is proposed between silhouette rendering techniques and pen-and-ink illustration for this study. The integration process of these rendering techniques takes on the lighting mapping and also the construction of colour region of the model in order to ensure the pen-and-ink illustration texture can be implemented into the object. The evaluation process is based on the visualization of the image from the hybridization process. Based on findings, the hybridization of NPR technique was able to create interesting results and considered as an alternative in producing new variety of visualization image in NPR.

ABSTRAK

Kajian ini mencadangkan kajian hibrid terhadap Teknik Lorekan Bukan Fotorealistik. Lorekan Bukan Fotorealistik meliputi satu bahagian di dalam komputer grafik iaitu menghasilkan pelbagai jenis data 2D digital daripada sumber data 3D contohnya hasil yang kelihatan seperti lakaran dan lukisan. Jenis lorekan ini meliputi interpretasi, luahan dan stail artistik. Kajian Lorekan Bukan Fotorealistik berdepan dengan pelbagai isu antaranya ialah penggayaan yang didorong oleh persepsi manusia, sains dan seni yang dibawa bersama dan disatukan melalui penggunaan teknik-teknik tertentu. Beberapa teknik yang digunakan di dalam lorekan bukan fotorealistik telah dibincangkan seperti teknik lorekan kartun, teknik lukisan cat air, teknik lorekan bayang, teknik ilustrasi pen dan dakwat dan lain-lain. Rancangan penghibridan Teknik Lorekan Bukan Fotorealistik diutarakan antara teknik bayang dan teknik ilustrasi pen dan dakwat bagi kajian ini. Proses integrasi antara kedua-dua teknik lorekan ini memerlukan pemetaan cahaya dan penstrukturan warna kawasan bagi memastikan tekstur ilustrasi pen dan dakwat boleh diimplemen pada objek. Proses penilaian adalah melalui visualisasi imej hasil proses penghibridan. Berdasarkan penemuan kajian, teknik hibrid boleh mewujudkan imej yang menarik dan dapat dijadikan sebagai alternatif bagi penghasilan pelbagai imej lorekan bukan fotorealistik yang baru.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATION

LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
NPR	Non-photorealistic Rendering

CHAPTER 1

INTRODUCTION

1.1 Introduction

Computer graphics basically deals with the process of generating pictures on the computer screen or display. In other words, it is actually a technology that is able to produce an image or illustration using computer. Precisely on computer graphics definition is the image data that being created with the aid of graphical hardware and software. The production of this illustration is actually to convey messages and information (Markosian *et al*.,1997).

Rendering is one of the research areas in computer graphics. Rendering process is focused on generating or producing an image from models or scene file by computer programme. In simple explanation, rendering is the process of combining multiple scene information. The content of a scene file is defined by specific language or data structure. The scene descriptions are geometry, viewpoint, texture, lighting, and shading information. The content of the scene file is then passed to rendering program to be processed and to generate the image file either into digital or raster file.

Figure 1.1 shows the steps involved in rendering process. 3D scene was generated by the computer. The scene is being rendered flat into 2D view part with different

rendering algorithm. There are colour, texture, lighting and also shading added into the scene. It starts from only a simple outline image, progressing into an advanced image with shading and reflection. The time consume for rendering will be faster in simple image instead of the sophisticated image.

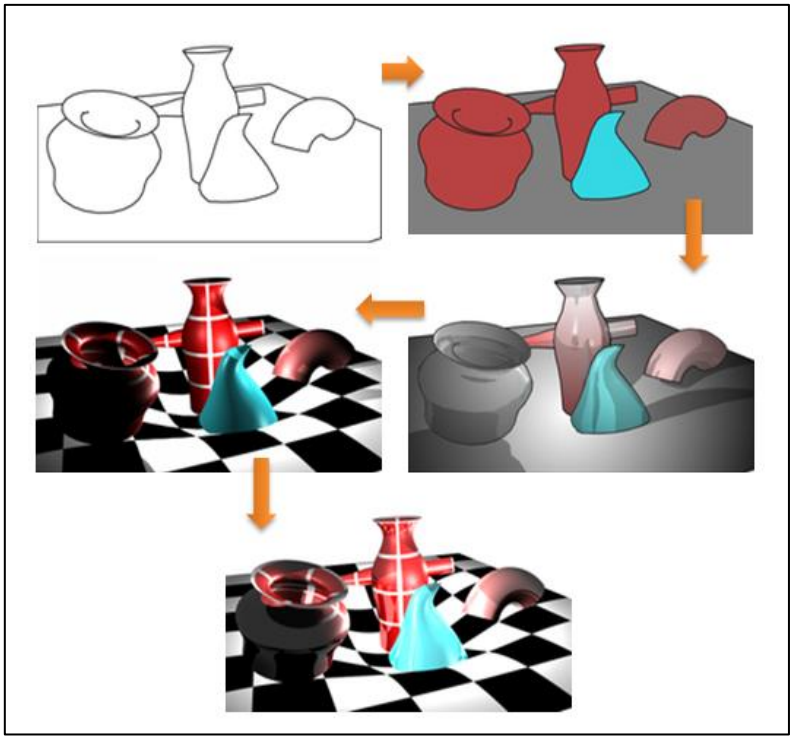

Figure 1.1: Example of steps in Rendering Process

Photorealism is one of the areas in computer graphics research. It is an art that embrace the drawing, painting and other kind of graphic media which aims to produce realistic image. Realistic image is generating the image that looks real include the physics of light, the surfaces and the materials. In concept of rendering, photorealistic is a concept of image viewing by converting the representation of the virtual scene. There is variety of characteristic that included in this rendering such as the reflection, refraction, light and material properties. The lighting helps to visualize more on realism of the object such as flat shading, gouraud shading and phong shading. Zhang and Han (2013) stated that Phong shading is a shading model that can generate realistic image. Other than that, radiosity, ray tracing, and image based rendering also related to photorealistic rendering. These materials will help in producing the better product of photorealistic rendering.

Photorealism used simulation approach and usually physical based are being chosen for the simulation. Figure 1.2 shows the process of photorealistic rendering process from basic view, lighting and shading implementation until the objects looks real.

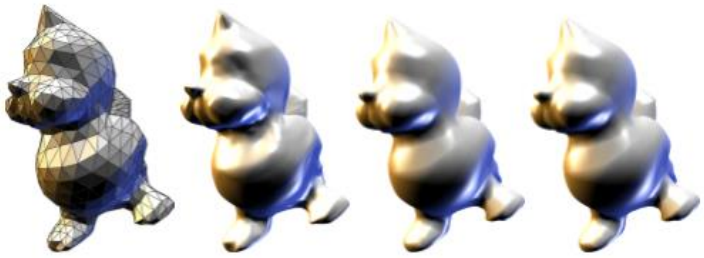

Figure 1.2: Photorealistic Rendering Process(Boubekeur and Alexa, 2008)

Non-photorealistic Rendering (NPR) is a part in computer graphics that basically emphasize the digital art styles. Raskar *et al.*(2006) also claims that NPR is one of the method in computer graphics to generate the artistic and stylized image. NPR includes the painterly, interpretative, expressive and artistic style. NPR approaches is the stylization process which is driven by human perception, the science and art which bring together and being harmonized. NPR focused on the product, concern more on how the result will show instead of giving more concentration on the process. Figure 1.3 shows the example of NPR result of a 3D object.

Figure 1.3: Example of NPR result on a teapot 3D object

Implementing the Non-photorealistic Rendering in computer graphics actually aims to show many kind of abstract and illustration view. NPR may not replace the value of true artistic arts, but it may help us to create new knowledge on how to implement the NPR in order to get the mostly similar product of artistic arts.

1.2 Problem Background

Non-Photorealistic Rendering is actually one of computer graphics area which focused on techniques and method in producing images of artistic and illustrative styles. In computer graphics, creating image that closely resembles the original are among of the main things.

Through lots of cases, Haevre *et al*. (2005) found that rendering scene by using photorealistic could not be the optimal solution. In contrary, non-photorealistic can help simplify the complex objects and gives hand in forwarding the information based on Claes *et al.* (2001). Other than that, Gooch *et al.* (1999) stated that producing images with the artistic value and style which likely appear as images that made by artist is the NPR goals. Applying non-photorealistic rendering is thought to be more adequate than photorealistic rendering in same situation such as physical structure or phenomena.

For years, human create illustration for medical, artistic, scientific and entertainment by hand. Eventually the existence of computer graphics is likely to help illustration to be more advanced by having techniques such as Non-photorealistic Rendering to create images. Besides that, visual abstractions are needed for conveying and communicate the information in effective way. Redmond and Dingliana(2008) said that NPR can comprehend faster and simpler as they can create simple rendering of complicated scene. This kind of abstraction is actually being studied in graphics and traditional illustration. Lansdown and Schofield (1995) stated that, instead of photorealism which actually already had its own place in industries, stylized illustration is often looking more effective which can be done by NPR.

In NPR, there are different types of techniques that are available such as silhouette rendering which can help to show the boundaries of the object, painterly rendering representing the image that illustrate as painting drawing, pen-and-ink illustration illustrate the image in many styles of strokes and lines, watercolour rendering interpreted the image to look exactly like canvas drawing, and technical illustration is used to visually communicate the information in the image. Each of these techniques can produce different stylization images.

The hybrid method had been introduced in NPR in order to improve the result of the NPR techniques. There are some researchers that had been working on the hybrid methods in previously. Saito *et al.*(1990) and Raskar *et al.* (1999) claimed that determining the front face and the back face of the object is the problem arise in silhouette rendering. Applying the z-buffer representation along with the front and backface culling is the hybridization methods which has overcome the problem. Bu *et al.*(2006) claimed that the drawing from this kind of technique actually shows the drawing to be more natural and more art-stylized if only the strokes generated and the direction of the strokes can be controlled wisely.

Redmond and Dingliana(2008) had used painterly rendering and silhouette rendering. They employed hybridization of image space and object space to create a fast and effective result. Al-Rousan *et al.*(2015) had done hybridization on shading effect and stylized line drawing to create the toon shading effect. Other than that, another example of hybrid was techniques of NPR presented by Lee *et al.*(2015) which had implemented three NPR method; silhouette rendering, cartoon rendering and hatching rendering in order to get over the weakness of 3D map application. Since hybridization method can enhanced and produced more styles in digital artwork, this research proposed a hybridization method to give a new stylized visualization using NPR techniques.

1.3 Problem Statement

Enabling variety of expressive styles for digital art is the goals of the NPR. Hence, this research proposes a hybridization of Non-photorealistic Rendering technique in order of producing a new stylized illustration in NPR.

Among of expressive digital art style and stylization images in NPR that can be produced are imitating traditional artistic styles by using computer-generated image. Pen-and-ink illustration techniques suits well as traditional forms of art expression implies in this method. Other than that, effective conveying lighting, direction and texture is claimed by Jia *et al.*(2006) to be more effective in this technique. Hybridization will enhanced the output images in NPR, hence another technique is added in producing computer-generated images of traditional artistic styles which are silhouette rendering. Tracing object outline can be made by silhouette edges which by using few strokes, object size and shape can be portrayed in the scene by Sayeed and Howard(2006). In addition, Lee *et al.*(2015) claims that silhouette helps in extracting the outlining the model. By combining both techniques, the process of generating computer-generated image that emulates traditional artistic style can be achieve well.

The research questions that will be addressed to achieve goal in this study as follow:

i) How to integrate the silhouette rendering technique and pen-and-ink illustration technique?

ii) How to evaluate the result of the hybridization of the silhouette technique and pen-and-ink illustration technique?

1.4 Aim of Study

The aim for this research is to propose a hybrid of NPR techniques based on the silhouette rendering technique and pen-and-ink illustration in producing a styled image for 3D object.

1.5 Objective of Study

In order to actualize the aim of this project, these objectives need to be achieved:

1. To find a way to integrate silhouette technique and pen-and-ink illustration into hybrid NPR technique for 3D object in 3D scene
2. To implement stylized illustration of formulated hybrid NPR technique of silhouette rendering and pen-and-ink illustration for 3D object in 3D scene
3. To evaluate the NPR result of the hybrid NPR techniques of silhouette and pen-and-ink illustration rendering techniques

1.6 Scope of Study

The scope for this study is limited to 3D objects which include the primitives shape such as torus, sphere, cylinder and pyramid and also the standard 3D objects normally used in computer graphics experiments such as stanford bunny, teapot, porsche, and tricera. Source of 3D objects are from various repository as listed in Table 1.1.

Table 1.1: Repository source of 3D object

Primitives Object	Primitives object that included as input in this research are sphere, torus, cylinder, and pyramid. Following are the repository source for these objects: 1) http://forum.runtimedna.com/showthread.php?104988-Primitives&104988-Primitives=&p=953889&viewfull=1 2) \http://www.sweethome3d.com/fr/freeModels.jsp
Standard Object	Standard object that included as input are the bunny, teapot, tricera and also the porsche. Following are the repository source for these objects: 1) http://people.sc.fsu.edu/~jburkardt/data/obj/obj.html 2) http://tf3dm.com/3d-model/puo-63645.html 3) https://graphics.stanford.edu/~mdfisher/Data/Meshes/bunny.obj 4) http://tf3dm.com/3d-model/porsche-911-gt-43465.html

1.7 Significance of Study

Based on the Non-photorealistic Rendering study on techniques and method implemented, they can produce many stylized kind of artistic and illustration view which meet the demand of artistic value.

1.8 Organization of Study

Below are the brief content descriptions of the subsequent chapters of this project report:

i) Chapter 1 describes the concept of this project in details by discussing the introduction of this study, problem background, aim, objectives, scope and also the justification of this project.

ii) Chapter 2 is a about the history of Non-photorealistic Rendering (NPR) and literature review on the techniques and methods implemented in NPR. Review paper of previous work and the research done related to this topic is also described in this chapter.

iii) Chapter 3 presents the research methodology and gives detailed description on the proposed framework. This chapter also describes the data sources and preparation, software and hardware specification that will be used for this project.

iv) Chapter 4 will show the algorithm of each technique that being implemented and this chapter also displaying the interface prepared for the research of hybridization of NPR technique.

v) Chapter 5 will explain and displaying the result of the hybridization of NPR technique which covers the result for each technique implemented and the final result of the hybridization.

vi) Chapter 6 are discussing the process of hybridization of NPR technique including the achievement of the objectives, problems arise during research work being done, contribution of the research towards NPR and also the recommendation for future work.

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